Technical Note on CERES EBAF Ed2.6r

TOA Incident Shortwave Radiation (rsdt)

1. Intent of This Document and POC

1a) This document is intended for users who wish to compare satellite derived observations with climate model output in the context of the CMIP5/IPCC historical experiments. Users are not expected to be experts in satellite derived Earth system observational data. This document summarizes essential information needed for comparing this dataset to climate model output. References are provided at the end of this document to additional information.

This NASA dataset is provided as part of an experimental activity to increase the usability of NASA satellite observational data for the modeling and model analysis communities. This is not a standard NASA satellite instrument product, but does represent an effort on behalf of data experts to identify a product that is appropriate for routine model evaluation. The data may have been reprocessed, reformatted, or created solely for comparisons with climate model output. Community feedback to improve and validate the dataset for modeling usage is appreciated. Email comments to HQ-CLIMATE-OBS@mail.nasa.gov.

Dataset File Name (as it appears on the ESG):

rsdt_CERES-EBAF_L3B_Ed2-6r_200003-201206.nc

1b) Technical point of contact for this dataset:

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2. Data Field Description

CF variable name, units:	TOA Incident Shortwave Radiation (rsdt), Wm^{-2}
Spatial resolution:	1°x1° latitude by longitude
Temporal resolution and extent:	Monthly averaged from 03/2000 to 06/2012
Coverage:	Global

3. Data Origin

The CERES science team provides monthly regional mean TOA incident shortwave radiation derived from the Total Solar Irradiance (TIM) instrument aboard the Solar Radiation and Climate Experiment (SORCE) satellite. The TIM instrument measures the absolute intensity of solar radiation, integrated over the entire solar disk and the entire solar spectrum reported at the mean solar distance of 1 astronomical unit (AU). The SORCE spacecraft was launched on January 25, 2003 and became operational on February 25. It launched into a 645 km, 40° orbit and is operated by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado (CU) in Boulder, Colorado, USA. The CERES product uses the daily fluxes from the SORCE web site at:
http://lasp.colorado.edu/sorce/tsi_data/daily/sorce_tsi_L3_c24h_latest.txt
from February 25, 2003 until Dec 31, 2010 using version 11. The daily fluxes are updated from this site on a regular basis and there usually is a 2-month data lag from real-time. From March

2000 until February 24, 2003 the composite_d41_62_0906.dat dataset from Froehlich and Lean 1998 is used with an offset value of -4.4388599 Wm^{-2} to put the daily fluxes on the same radiometric scale as SORCE. These are available from: ftp://ftp.pmodwrc.ch/pub/data/irradiance/composite/.

The Froehlich and Lean fluxes are derived from 6 independent space based radiometers since 1978 using overlap time periods to normalize the fluxes to a common reference. The fluxes are observed from the Hickey-Frieden (HF), Active Cavity Radiometer Irradiance Monitor (ACRIM 1, II and III), Earth Radiation Budget Satellite (ERBS) and Variability of solar Irradiance and Gravity Oscillations (VIRGO) missions. The basis for 2000-2003 was mainly from VIRGO. Figure 1 displays the SORCE data in red and the pre-SORCE solar irradiance records adjusted to SORCE composite daily fluxes in blue. On the rare occasion that the daily flux is missing it is linearly interpolated from the nearest daily measurements. It must emphasized that CERES EBAF Edition 2.6r, the basis of this dataset, uses daily varying SORCE TOA solar incoming irradiances, which have a long term mean of ~1361Wm^{-2}. Earlier versions of CERES and Earth Radiation Budget Experiment (ERBE) used a constant solar irradiance of 1365 Wm^{-2}.

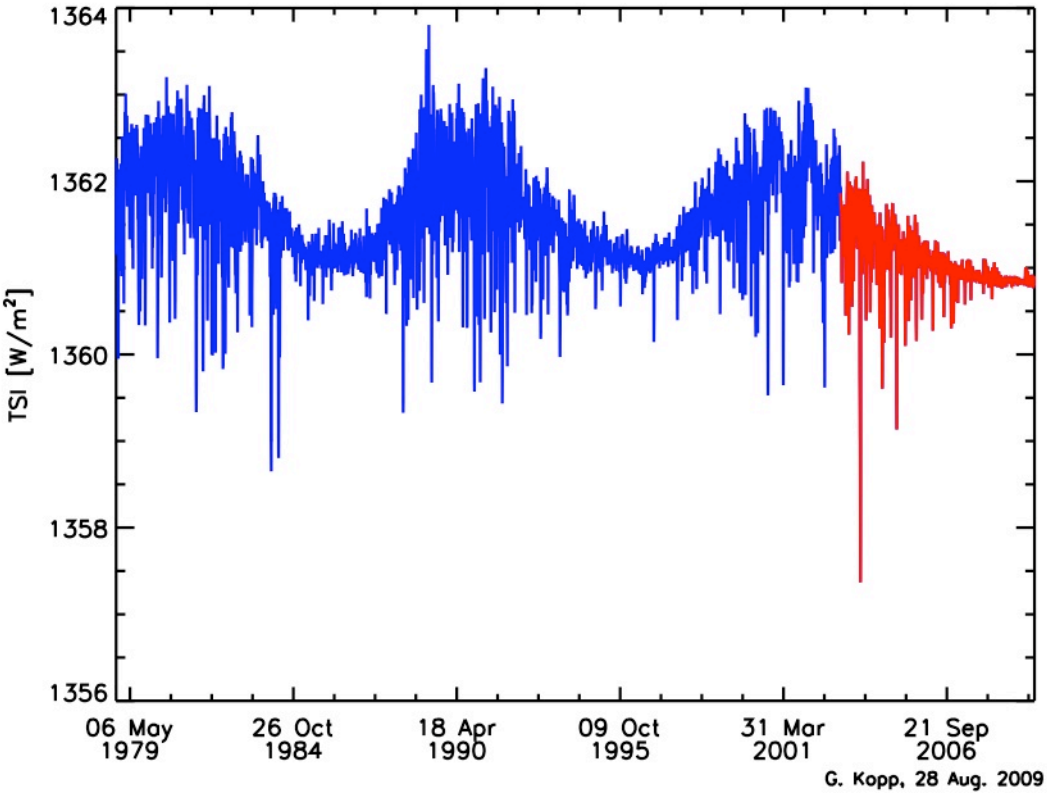

Figure 1. The Froehlich and Lean (1998) composite TOA solar incoming fluxes in blue and the SORCE TIM daily fluxes in red beginning on February 25, 2003.

To compute the solar incoming irradiance for a given region as a function time, CERES uses JPL DE200 to compute the daily earth-sun distance and the Consultative Committee for Space Data Systems CCSDS 301.0-B-2 (1994) almanac to compute the daily solar declination angle and sidereal day or right ascension or hour angle. The CCSDS database can be downloaded at

http://public.ccsds.org/publications/SilverBooks.aspx and the JPL DE200 at http://heasarc.nasa.gov/listserv/heafits/msg00050.html. The regional solar zenith angle or solar insolation is then computed analytically, as referenced in Liou 1980.

CERES uses geodetic weighting to average the zonal fluxes into a global mean. This assumes the earth is an oblate spheroid with an equator radius of 6378.137 km and polar radius of 6356.752 km. This increases the annual global incoming solar flux by 0.29 Wm^{-2} over weighting assuming a spherical earth (Loeb et al 2009).

To derive the net TOA flux the SW and LW outgoing flux is subtracted from the SW solar incoming flux. As in previous versions of EBAF (Loeb et al., 2009), the CERES SW and LW fluxes in EBAF Ed2.6r are adjusted within their range of uncertainty to remove the inconsistency between average global net TOA flux and heat storage in the earth–atmosphere system, as determined primarily from ocean heat content anomaly (OHCA) data. In the current version, the global annual mean values are adjusted such that the July 2005–June 2010 mean net TOA flux is 0.58±0.38 Wm^{-2} (uncertainties at the 90% confidence level). The uptake of heat by the Earth for this period is estimated from the sum of: (i) 0.47±0.38 Wm^{-2} from the slope of weighted linear least square fit to ARGO OHCA data (Roemmich et al., 2009) to a depth of 1800 m analyzed following Lyman and Johnson (2008); (ii) 0.07±0.05 Wm^{-2} from ocean heat storage at depths below 2000 m using data from 1981–2010 (Purkey and Johnson, 2010), and (iii) 0.04±0.02 Wm^{-2} from ice warming and melt, and atmospheric and lithospheric warming (Hansen et al., 2005; Trenberth, 2009). This results in a net flux balance of 0.58 Wm^{-2} for the CERES 10-year record.

4. Validation and Uncertainty Estimate

The TIM Total Solar Irradiance (TSI) measurements monitor the incident sunlight to the Earth's atmosphere using an ambient temperature active cavity radiometer. Using electrical substitution radiometers (ESRs) and taking advantage of new materials and modern electronics, the TIM measures TSI to an estimated absolute accuracy of 350 ppm (0.035%). Relative changes in solar irradiance are measured to less than 10 ppm/yr (0.001%/yr), allowing determination of possible long-term variations in the Sun's output (Kopp et al. 2005).

5. Considerations for Model-Observation Comparisons

The solar incoming TOA flux is derived from daily SORCE TIM measurements, which has an average annual flux of ~1361 Wm^{-2}, varies with time, and takes into account the solar sunspot cycle with an amplitude of ~0.1%.

6. Instrument Overview

The first paragraph under section 3 gives an overview of the SORCE TIM instrument.

7. References

The full version of CERES EBAF Ed2.6r is available from the following ordering site:

http://ceres.larc.nasa.gov/order_data.php

Fröhlich, C., and J. Lean (1998), The Sun's total irradiance: Cycles, trends and related climate change uncertainties since 1976, Geophys. Res. Lett., 25(23), 4377-4380.

Hansen, J. et al. Earth's energy imbalance: confirmation and implications. Science **308**, 1431–1435 (2005).

Kopp, G. and Lawrence, G., "The Total Irradiance Monitor (TIM): Instrument ; Design," Solar Physics, 230, 1, Aug. 2005, pp. 91-109.

Liou, Kuo-Nan, 1980, An introduction to atmospheric radiation. Academic Press New York.

Loeb, N. G., B. A. Wielicki, D.R. Doelling, G. L. Smith, D. F. Keyes, S. Kato, N. Manlo-Smith, T. Wong, 2009, Toward Optimal Closure of the Earth's TOA Radiation Budget, Journal of Climate, 22, pg 748-766, DOI: 10.1175/2008JCLI2637.1

Purkey, S.G., and G.C. Johnson, 2010: Warming of global abyssal and deep southern ocean waters between the 1990s and 2000s: contributions to global heat and sea level rise budgets. J. Clim **23**, 6336–6351.

Roemmich, D. et al. Argo: the challenge of continuing 10 years of progress. Oceanography **22**, 46–55 (2009).

Trenberth, K.E., 2009: An imperative for climate change planning: tracking Earth's global energy. Current Opinion in Environmental Sustainability **1**, 19–27.

8. Revision History

[Document changes in the dataset and the technical note if a new version supersedes an older version published on the ESG.]

Rev 0 – 08/09/2011 – This is a new document/dataset

Rev 1 – 03/05/2012 – Updated to Edition2.6r. EBAF Ed2.6r corrects a code error in the calculation of global mean quantities in EBAF Ed2.6. Also updates temporal extent to 06/2011 from 12/2010.

Rev 2 – 06/06/2012 – Updated temporal extent to 12/2011 from 06/2011.

Rev 3 – 11/01/2012 – Updated temporal extent to 06/2012 from 12/2011.